

# ***U.S. PATENT APPLICATION***

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***Invention:*** OPTICAL DEVICE FOR EMITTING A LASER LIGHT BEAM, OPTICAL  
READER COMPRISING SAID DEVICE AND PROTECTIVE/INSULATING  
PACKAGE FOR A LIGHT BEAM EMISSION SOURCE

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## ***SPECIFICATION***

Optical device for emitting a laser light beam, optical reader comprising said device and protective/insulating package for a light beam emission source.

#### DESCRIPTION

5 The present invention relates to an optical device for emitting a laser light beam, and to an optical reader comprising said device.

The invention also relates to a protective and/or insulating package for a light beam emission source; said  
10 package is especially adapted to be used in the device and/or in the optical reader of the present invention.

The invention also relates to an optical device for emitting a light beam and for the simultaneous collection of the light diffused by an illuminated optical code, and  
15 to an optical reader comprising such emission/reception device.

Preferably but not exclusively, the emission device, the package or the emission/reception device of the invention are adapted to be used, in particular, in a small-size and  
20 low-cost optical reader, such as for example a portable optical code reader.

In the present description and following claims, the term: optical reader refers to any device capable of acquiring coded information relating to an object (for example  
25 distance, volume, size, or its identification data) through the acquisition and the processing of a luminous signal diffused by it. The term: optical code, on the other hand, refers to a code (such as for example, a bar code, a bi-dimensional code or the like) capable of univocally  
30 identifying the objects on which it is provided.

For exemplificative purposes and in order to make the following discussion clearer, in the following description explicit reference shall be made to optical code readers.

In its simplest embodiment, an optical code reader comprises a source for the emission of a luminous signal intended to illuminate an object, photo-detecting means intended to collect the luminous signal diffused by the illuminated object and generate an electrical signal proportional thereto, and processing means intended to elaborate and process the generated electrical signal, so as to acquire the desired information. Downstream of the emission source, moreover, a focusing lens intended to focus, at a predetermined distance, the luminous signal emitted by the emission source can be placed.

As known, above all in small-size and low-cost optical readers, there is the need of using low-priced and small devices for emitting a focused light beam and/or focusing devices. For this purpose, as emission source, the use or semiconductor laser diodes is still widely diffused.

A semiconductor laser diode essentially comprises a chip of semiconductor material (with size typically comprised in the ranges 200-300  $\mu\text{m}$  in depth, 250-300  $\mu\text{m}$  in width and 100-150  $\mu\text{m}$  in height) which, due to its extreme sensitivity to atmospheric agents and to electrostatic charges, is properly fixed on a special support element and housed into a special package which insulates and/or protects it from the external environment; the package essentially consists of a metal capsule having a substantially cylindrical shape. At a first end thereof, said capsule is provided with a base surface comprising seats intended to receive respective electric connection elements for power-supplying the diode and at an opposed end, with a service surface comprising a glass window to allow the emission of the light beam generated by the diode. The chip support element also functions as heat sink for the diode during operation.

Typically, the windows of the semiconductor laser diodes are manufactured in such a way as to allow the exit of the highest possible quantity of luminous energy, thus exploiting all the luminous power of the laser without

reducing its efficiency; thus, they are of relatively large size.

However, the use of a semiconductor laser diode, if on the one hand allows to obtain an advantage in terms of overall costs and size of the emission and/or focusing device (and thus, of the reader), on the other hand exhibits the disadvantage of not allowing a reliable reading of optical codes, also when they are arranged at a short distance from the reader. This is essentially due to the impossibility of generating a light beam which should remain collimated and focused for a predetermined, even small, distance range.

Therefore, in the optical readers there is the need of producing a focused laser beam also for small depths of field, so as to allow a reliable reading of optical codes arranged even at a short distance; this implies the need that the spot of the laser at the focal point should have a diameter substantially equal to or slightly greater (1.5 times) than the size of the module (that is, of the smallest element of the code) of optical information that must be read, and that the spot should remain such for a predetermined propagation distance.

A method known in the art for obtaining a sufficient depth of field provides for the step of manipulating the laser beam exiting from the laser diode using the effects produced by an aperture (diaphragm) intended to let only a central portion of the emitted laser beam pass.

In fact, it is known that whenever a luminous wave front passes through an aperture of any shape, but anyway such as to truncate the wave front, the distribution of the luminous intensity downstream of the same aperture is determined by the diffraction. Said distribution is called diffraction pattern and corresponds to the spot of the laser beam at the focal point; its shape and size depend on the size of the aperture, on the distance from which the pattern is observed, and from the radius of curvature of

the incident wave front (if the incident wave front is plane, the radius is infinite).

The shape of the diffraction pattern depends on a parameter which contains all of the possible variants indicated above; said parameter is known as Fresnel number, and is defined by the following relation:

$$N=a^2/(\lambda \cdot Z)$$

wherein a is the semi-dimension of the aperture in the direction in which the spot diameter is measured,  $\lambda$  is the wavelength and Z is the effective observation distance (in the case of a plane wave front, Z is the actual observation distance; in the case of a curved wave front, the effective observation distance differs from the actual observation distance by the radius of curvature of the wave front).

In substance, the main effects of the diffraction from an aperture are both that of increasing the size of the laser beam at the focal point, and that of maintaining the spot collimated and substantially with the same profile for a greater distance interval, and finally that of giving a more suitable shape to the spot for an optional reading of optical codes (in particular, a spot is obtained having an intense and focused central portion). In this way, there is the advantage of increasing the reading field (depth of field).

Often, it is actually desirable to be able to read coded information on optical supports placed into a very wide range of distances; that is, the reader must have a high reading field (either depth of focus, or depth of field). Such need can occur, for example, in handling plants for distributing and sorting objects identifiable through optical codes, in which said objects can have also very different heights from one another. In this case, the laser spot must remain focused for a propagation distance as wide as possible.

A method known in the art for obtaining a high depth of field provides for the step of manipulating the laser beam exiting from the laser diode, using the combined effects of the focusing device (lens) and of an aperture (diaphragm) intended to let only a central portion of the emitted laser beam pass. In substance, it has been experimentally proven that adding up the effects of the focusing produced by the lens and of the diffraction produced by the aperture, it is possible to obtain a focused light beam with particularly high depth of field.

By combining the focusing effect of the laser beam produced by the focusing lens, and that of diffraction due to the interposition of an aperture between the lens and the focal point (or between the emission source and the lens), a spot whose shape is the diffraction pattern corresponding to the aperture, scaled in size by a factor depending on the magnification or reduction operated by the lens is obtained at the focal point and in its surroundings. This allows to perform reliable readings at different and relevant distances.

Although the introduction of diffraction in a light beam through an aperture produces an increase of the light beam spot size at the focal point and a reduction of the luminous efficiency of the reader, it is particularly advantageous when on the one hand, an excessive focusing of the spot is to be prevented (for example, so as not to detect the support imperfections) and on the other hand, the reading field of the reader it to be maximised.

In the prior art there are known laser readers which take advantage of the combined effect of the focusing and of the diffraction of a laser beam for the purpose of increasing the reading field of the same reader. For example, the European patent application EP 367 299 describes a laser diode scanning device for reading bar codes comprising a semiconductor laser diode associated to a diaphragm and to a focusing lens. In such a device, particular attention

must be given in the relative arrangement of the diaphragm and of the focusing lens for the purpose of obtaining the desired focusing and diffraction effects and to allow a reliable reading. In fact, it is necessary to provide a  
5 suitable mechanical coupling, support and alignment system between diode, diaphragm and lens; this unavoidably implies high costs and high assembly times. Moreover, the presence of several individual optical components (diode, diaphragm, focusing lens), each to be arranged in a suitable way with  
10 respect to the others, makes an excessive miniaturisation of the device impossible.

The technical problem at the basis of the present invention is that of providing a device for emitting a light beam which should, on the one hand, be constructively simple,  
15 easy to mount, low-priced and small-sized, so as to be mounted, for example, into small-sized and low-priced optical readers (such as, for example, portable readers), and on the other hand should allow to obtain all the advantages of introducing diffraction in the emission laser  
20 beam (in particular, an increase of the depth of field of the device and/or reader).

Thus, in a first aspect thereof, the present invention relates to an optical device for emitting a laser light beam, comprising:

- 25 - a laser light beam emission source including a package and means for generating the laser light beam housed into said package, the package being provided with a laser light beam emission window;  
- a diaphragm intended to select a central portion of the  
30 laser light beam;  
characterised in that said package comprises said diaphragm.

Advantageously, the device of the present invention is provided with a diaphragm intended to introduce diffraction  
35 in the laser light beam generated by the emission source, so as to obtain an increase of its depth of field. Even

more advantageously, said diaphragm is structurally associated to the protective and/or insulating package of the luminous source, and it is part of said package; this allows to obtain a significant reduction of the overall dimensions of the emitting device and thus, of the optical reader wherein it is intended to be mounted. Moreover, the device of the invention is particularly simple from the construction point of view, and it provides for the use of widely used optical elements: this implies a reduction of the production costs.

Thus, according to the present invention it is possible to generate directly at the outlet of the package of the emission source a laser light beam with assigned cross section and sufficient depth of field. Considering the precision with which modern assembly methods allow to arrange the light source with respect to the package window, it is possible to obtain a laser light beam at the output of the package, which is already ready to be optionally focused without further need of being truncated downstream of the package. The disadvantage mentioned above with reference to the devices of the prior art - associated in particular to the need of taking care of the optical alignment of the diaphragm with the emission window - is thus removed.

The above advantages are particularly evident when the laser light beam emission source is a semiconductor laser diode, although it is possible to achieve the same advantages with other type of sources comprising special protective packages provided with a window for the emission of the light beam.

In a first embodiment of the device of the present invention, the diaphragm is directly associated to the package at the laser light beam emission window. More preferably, the diaphragm is directly housed into the laser light beam emission window.



In a particularly advantageous embodiment of the device of the present invention, the laser light beam emission window is shaped so as to be itself a diaphragm. Advantageously, thus, the emission source is implemented with smaller size  
5 and shape than that of the laser light beam in a transversal cross section taken at said laser light beam emission window so as to impart assigned shape and size to said beam, concurrently introducing diffraction into it. According to the present invention, it is thus sufficient  
10 to suitably shape the package window to obtain the desired diffraction effects. In other words, a single optoelectronic element (package) is realised, having an emission diaphragm/window with predetermined shape and size.

As already said, the device of the present invention is preferably intended to be mounted into an optical reader, for example an optical code reader. The optional optical code reading can be carried out prevalently along a preferential direction or along more directions (omnidirectional reading). According to the present invention,  
20 for the purpose of allowing a reliable reading of codes prevalently oriented orthogonally to the reading (or scanning) direction, the emission window defines an aperture having a Fresnel number smaller than 2  
25 (preferably, smaller than 1.2) along the reading direction and smaller than 6 in orthogonal direction. Even more preferably, for the purpose of carrying out reliable readings along all directions, independently of the code orientation with respect to the reader, the aperture  
30 defines a Fresnel number smaller than 2 along all directions.

As already said, the shape of the diffraction pattern (spot) generated by an aperture is a function of the Fresnel number defined by the following relation:

35

$$N = a^2 / (\lambda \cdot Z)$$

where  $a$  is the semi-dimension of the aperture in the direction in which the spot diameter is measured,  $\lambda$  is the wavelength and  $Z$  is the effective distance of observation. By suitably selecting the Fresnel number, it is therefore  
5 possible to select each time the shape of the spot laser that allows to obtain a reliable reading.

According to a particularly preferred embodiment thereof, the device of the present invention further comprises a focusing lens. It is thus possible to obtain all the  
10 advantages described above arising from the combination of the effects of the focusing and of the diffraction.

According to an embodiment of the device of the present invention, the focusing lens is directly associated to the package at said light beam emission window. For the purpose  
15 of guaranteeing a greater safety in the stable coupling between focusing lens and laser light beam emission window, the device of the invention preferably further comprises an adhesive between the focusing lens and the emission window.

In a particularly advantageous embodiment of the device of the present invention, the focusing lens is housed in the laser light beam emission window, and is itself said diaphragm. Preferably, the focusing lens is a Fresnel or diffractive lens. In fact, it is advantageously possible to realise - through optical lithography methods - very small  
20 and thin Fresnel or diffractive lenses, which can be produced in plastic through repetition, at an extremely reasonable price. Such lens is itself the window/diaphragm of the package of the laser light beam emission source and allows to obtain all the advantages arising from the  
25 combination of the diffraction and focusing effects described above.  
30

In any case, independently of the chosen type of embodiment, the integration of the focusing lens in the package of the emission source allows to further reduce the  
35 overall size of the optical reader wherein the device of

the invention is intended to be mounted. Moreover, the disadvantage mentioned above with reference to the devices of the prior art, in particular that one associated to the need of taking care of the optical alignment of the focusing lens with the emission source and with the diaphragm, is thus eliminated.

In an alternative embodiment of the device of the present invention, the package has a substantially tubular shape with a longitudinal axis Z and wherein the light beam emission source is arranged into the package so that the emitted light beam propagates along a substantially perpendicular direction with respect to said longitudinal axis Z. This is particularly advantageous if, for example, due to requirements of smaller overall dimensions, it is necessary that the light beam emerges at a very low height with respect to a plane for the assembly of the package, or when, due to assembly requirements, the beam must propagate in parallel with respect to the surface on which all optoelectronic components of the emission source are mounted. Such embodiment is advantageously compatible with all the embodiments described above.

In a particularly preferred embodiment of the device of the invention, said package exhibits a cavity divided into two optically separate portions, respectively first and second portion, intended to respectively house said means for generating a light beam, and photo-receiving means for detecting a luminous signal diffused by an optical code illuminated by said means for generating a light beam, wherein on a first wall of said first cavity portion there is formed said emission window, and on a second wall of said second cavity portion there is formed a window for collecting the light beam diffused by the illuminated optical code, said first and second wall being orthogonally orientated with respect to one another. A single emission/detection device is thus advantageously implemented, which allows to limit to the utmost the

overall dimensions of the reader in which said device is intended to be mounted.

A package of the type described above allows to take advantage of the typical arrangement of the components in a non-retroreflective scan reader. As known, in fact, in a scan reader of the above type the laser beam typically impinges at 45° on an oscillating or rotating mirror which generates a scan in orthogonal direction with respect to the laser beam emission direction; said laser beam then illuminates the optical code, and the light diffused by it is collected by a photodiode, whose surface must face the plane on which the code lies (that is, said surface is substantially parallel to the code plane), so as to face toward the code the maximum collecting surface.

In a second aspect thereof, the invention relates to an optical reader comprising a laser light beam emission device for illuminating an optical code, means for generating at least one scan on said optical code, photo-detecting means intended to collect a luminous signal diffused by the illuminated optical code and generate an electrical signal proportional thereto, and processing means intended to elaborate and process the electrical signal, characterised in that said laser light beam emission device is of the type described above.

Such reader is a small sized and low-priced device and allows to obtain all the advantages mentioned above with reference to the emission device of the present invention.

In a third aspect thereof, the invention relates to a protective and/or insulating package for a light beam emission source, comprising a cavity intended to house means for generating a light beam and a wall provided with a window intended to allow the emission of said light beam, characterised in that it comprises a diaphragm intended to select a central portion of the light beam. Such package is particularly suitable to be mounted into a device and/or a

reader of the type described above, thus allowing the achievement of the above mentioned advantages.

Preferably, said emission source is a semiconductor laser diode.

- 5 In a first embodiment of the package of the invention, said diaphragm is associated to said wall at said light beam emission window. Preferably, the diaphragm is housed in the light beam emission window.

- 10 In the preferred embodiment of the package of the present invention, said emission window is shaped in such way as to be itself said diaphragm.

According to a particularly preferred embodiment, the package of the invention can further comprise a focusing lens.

- 15 According to a further embodiment of the package of the present invention, the focusing lens is directly associated to the package at said light beam emission window. Preferably, in this case, an adhesive is interposed between the focusing lens and the emission window.

- 20 Preferably, the focusing lens is housed in the light beam emission window and it is itself said diaphragm. Even more preferably, the focusing lens is a Fresnel or diffractive lens.

- 25 According to an alternative embodiment, in the package of the present invention a longitudinal axis Z is defined and said means for generating the light beam is intended to be arranged into said cavity so that the emitted light beam propagates along a substantially perpendicular direction with respect to said longitudinal axis Z.

- 30 In a particularly preferred embodiment of the package of the invention, said cavity is divided into two optically separate portions, respectively first and second portion,

intended to respectively house said means for generating a light beam, and photo-receiving means for detecting a luminous signal diffused by an optical code illuminated by said means for generating a light beam, wherein on a first  
5 wall of said first cavity portion there is formed said emission window, and on a second wall of said second cavity portion there is formed a window for collecting the light beam diffused by the illuminated optical code, said first and second wall being orthogonally oriented with respect to  
10 one another.

Each of the above embodiments of the package of the invention allows to obtain the same advantage mentioned above with reference to the corresponding embodiment of the emission device described above.

15 In a fourth aspect thereof, the present invention relates to an optical device for emitting/detecting a luminous signal, comprising:

- a light beam emission source including a package, and means for generating the light beam housed into a first  
20 portion of said package wherein there is formed a light beam emission window;

- photo-receiving means intended to detect a luminous signal diffused by an optical code illuminated by said emission source;

25 characterised in that said photo-receiving means is housed into a second portion of said package which is optically separate with respect to said first portion, and provided with a window for collecting the luminous signal diffused by the illuminated optical code.

30 It is thus possible to realise a single emission/detection device which allows to limit to the utmost the overall dimensions of the reader in which said device is intended to be mounted. As already mentioned before with reference to the emission device described above, the  
35 emission/detection device of the present invention allows to take advantage of the typical arrangement of the

components in a non-retroreflective scan reader.

Preferably, the emission source comprises a semiconductor laser diode.

5 Even more preferably, said emission and collecting windows are formed on respective first and second walls of said package, orthogonally oriented with respect to one another, so as to prevent part of the emitted light from directly reaching the photo-receiving means.

10 In the preferred embodiment thereof, the device of the invention further comprises at least one diaphragm intended to select a central portion of the light beam.

15 In a first embodiment of the device of the invention, said diaphragm is directly associated to said package at said light beam emission window. Preferably, said diaphragm is housed directly into the light beam emission window.

20 In the preferred embodiment of the device of the invention, said light beam emission window is shaped so as to be itself the diaphragm. Preferably, the light beam emission window is smaller than the light beam in a transversal cross section taken at said laser light beam emission window .

25 Preferably, the emission window defines an aperture having a Fresnel number smaller than 2 (more preferably, smaller than 1.2) along a predetermined reading direction, and smaller than 2 along an orthogonal direction with respect to said reading direction.

30 According to a preferred embodiment thereof, the device of the invention also comprises a focusing lens. Said focusing lens can be directly associated to said package at said light beam emission window (in this case, preferably, the device would also comprise an adhesive interposed between the focusing lens and the light beam emission window) or, preferably, it can be housed in the light beam emission

window and be itself said diaphragm (in this case, preferably, it would be a Fresnel or diffractive lens).

Each of the two embodiments of the emission/detection device of the invention allows to obtain the same advantage  
5 mentioned above with reference to the corresponding embodiment of the laser light beam emission device described above.

Preferably, the emission/detection device of the present invention further comprises a wall made of an optically  
10 opaque material interposed between said first and second portion of the package so as to allow the optical insulation between said portions.

In a fifth aspect thereof, the present invention relates to an optical reader comprising a light beam emission device  
15 for illuminating an optical code, means for generating a scan on an optical code, a device for detecting the luminous signal diffused by the illuminated optical code and for generating an electrical signal proportional thereto, means for elaborating and processing said  
20 electrical signal, characterised in that said emission and detection devices consist of a single emission/detection device of the type described above.

In particular, it is a non-retroreflective scan reader having, advantageously, small size and low price; such  
25 reader allows to obtain all the advantages mentioned above with reference to the emission and/or emission/detection device of the present invention.

In a sixth aspect thereof, the present invention relates to a protective and/or insulating package for a light beam  
30 emission source, comprising a first cavity portion intended to house means for generating a light beam provided with a first wall wherein there is formed a window intended to allow the emission of said light beam, characterised in that it comprises a second cavity portion intended to house



photo-receiving means for detecting a luminous signal diffused by an optical code illuminated by said means for generating a light beam, and provided with a second wall wherein there is formed a window for collecting the luminous signal diffused by the illuminated optical code, said second cavity portion being optically separate with respect to said first cavity portion. Such package is particularly suitable to be mounted into an emission/detection device and/or optical reader of the type described above, thus allowing to achieve all the advantages mentioned above.

Preferably, said package comprises all the structural and/or functional features mentioned above with reference to the emission/detection device of the present invention.

Further features and advantages of the present invention will appear more clearly from the following detailed description of some preferred embodiments, made with reference to the attached drawings. In said drawings, - Figure 1 shows a perspective schematic and sectioned view of a conventional light beam emission source (in particular, it is a conventional semiconductor laser diode);

- Figure 2 shows a perspective, schematic and sectioned view of a light beam emission source according to the present invention (in particular, it is a semiconductor laser diode modified according to the present invention);

- Figure 3 shows a schematic sectioned view of an emission device of a laser light beam according to the present invention, including the optical element of figure 2;

- Figure 4 shows a schematic sectioned view of an alternative embodiment of the device of figure 3;

- Figure 5 schematically shows various types of diaphragms usable, respectively in the optical element of figure 2 and/or in the device of figure 3;

- Figure 6 shows a perspective, schematic and sectioned

view of an emission/detection device according to the present invention;

- Figure 7 shows a front, perspective, schematic and sectioned view of a portion of the device of figure 6;
- 5 - Figure 8 shows a rear, perspective, schematic and sectioned view of the portion of figure 7.

In figures 3 and 4, reference numeral 1 refers to an optical device for the emission of a laser light beam, according to the present invention. Device 1 is intended to  
10 be used in an optical reader of small size and moderate price (for example, a portable reader of optical codes) for the purpose of increasing the depth of field of the light beam, so as to allow the reading of information placed at different distances (also small) with respect to the same  
15 reader.

Device 1 comprises an emission source 2, for example a semiconductor laser diode, intended to emit a light beam 3, for example a laser beam. Laser beam 3 exiting from diode 2 can have elliptical cross section, as in the case of an  
20 edge-emitting laser, or circular, as in the case of a VCSEL laser (vertical cavity Surface Emitting Laser).

In the following description, explicit reference shall be made to a semiconductor laser diode as emission source of a laser light beam; however, the man skilled in the art shall  
25 understand that what said is similarly applicable to different kinds of emission sources, comprising in any case a protective package provided with a light beam emission window.

For the purpose of making the description of the device of the present invention and the differences with the devices  
30 of the prior art clearer, reference shall be first made to figure 1, which shows a semiconductor laser diode 2 of the conventional type (PRIOR ART).

Typically, a conventional laser diode 2 essentially

comprises a chip 4 of semiconductor material fastened on a special support element 5 and housed into a cavity defined into a special metal package (or capsule) 6 for protection and/insulation from the external environment, having a substantially tubular shape and wherein there is defined a longitudinal axis Z. At a first end thereof, the package 6 comprises a base surface 7 on which there are provided elements 8 (commonly indicated with the term of rheophores or pins) of electrical connection for feeding the diode 2 and a monitor photodiode 9. At an opposed end thereof, the package 6 comprises a service surface or wall 10 wherein there is formed a glass window 11 intended to allow the output of the light beam 3 generated by chip 4.

In conventional focusing devices and/or optical readers, downstream of the laser diode 2 there are generally provided a diaphragm, intended to select a central portion of the light beam 3, and a focusing lens intended to focus the light beam 3 at a predetermined reading distance.

Now, reference shall be made to figure 2, which shows a modified semiconductor laser diode 20, which is an example of an optical element for emitting a light beam implemented according to the present invention. Said optical element 20 is in turn intended to be mounted in the laser light beam emission device 1a according to the present invention (shows as a whole in figures 3 and 4).

From figure 2 it can be seen that the laser diode 20 of the present invention is similar to the conventional laser diode 2 described above and illustrated in figure 1, except at the service surface 10 of package 6. Thus, the structural elements of the laser diode 20 of the present invention that are identical to those described above with reference to the laser diode 2 of the prior art are indicated with the same reference numeral, whereas the different and/or modified structural elements are indicated with a different reference numeral.

According to a first preferred embodiment of the device of the present invention, shown in figures 2 and 3, the window 11 for the emission of the light beam 3 is shaped so as to be itself a diaphragm 12. In particular, the size and shape of window 11 are smaller than the size of the light beam 3 in a transversal cross section taken at the window itself, so as to impart assigned size and shape to said beam 3, concurrently introducing diffraction into it. Thus, diaphragm 12 is an integral part of the laser diode 20; more in particular, diaphragm 12 is integral part of package 6, forming with the latter a single optical element wherein a single window/diaphragm component 12 is realised.

Preferably, the window/diaphragm 12 defines in package 6 an aperture having a Fresnel number smaller than 2 (more preferably, smaller than 1.2) along the reading direction, and smaller than 6 (more preferably, smaller than 2) in orthogonal direction. In particular, for the purpose of carrying out reliable readings along all directions, independently of the orientation of the code with respect to the reader, the aperture defines a Fresnel number smaller than 2 along all directions.

In an alternative embodiment (less preferred) of the device and/or of the optical element of the present invention, not shown, instead of consisting of the emission window, diaphragm 12 is directly associated to package 6 at the window 11 for the emission of the light beam 3 (for example through the interposition of an adhesive), so as to define as a whole an aperture with a desired shape and size; in a second alternative embodiment (also not shown), diaphragm 12 is directly housed into the window 11.

Independently of the specific embodiment of the device and/or of the optical element of the present invention, the shape of diaphragm 12 can be chosen on the basis of the specific use provided for the device and/or reader in which said device and/or optical elements is intended to be mounted. For example, as already mentioned, the reading of

optical codes can be of the omni-directional type, or it can occur prevalently along a preferential direction. In the first case, it is advantageous to use a diaphragm of symmetrical shape (circular or square or rhomboidal, or one of these shapes differently bevelled - see to figure 5(a)); on the other hand, in the second case it is advantageous to use an elongated diaphragm in the orthogonal direction with respect to that of reading (elliptical or rectangular or rhomboidal or one of these shapes differently bevelled - see to figure 5(b)).

Device 1 (and/or the optical element 20) of the invention further comprises a focusing lens 13 of the truncated beam portion 3 (see to figure 3). Lens 13 is generally made of a plastic material transparent to the luminous radiation; however, any other material optically transparent and printable or shapeable in the desired shape can be used.

Lens 13 can be associated to and aligned with package 6 of the laser diode 20 according to any one of the modes described in the European patent application no. 99830677.3 by the same Applicant, and shown in figures 1, 2 and 3 of the same application, whose description is herein incorporated by reference. According to said modes, the lens 13 is arranged almost in contact with the window/diaphragm 12.

In an alternative embodiment of the device of the present invention, the focusing lens 13 is directly associated to the package 6 at the window/diaphragm 12. In this case, the device comprises an adhesive interposed between the window/diaphragm 12 and the lens 13, for the purpose of firmly associating the lens to package 6 of the laser diode 2.

In a particularly preferred embodiment of device 1 and/or of the optical element 20 of the present invention, the focusing lens 13 is integral part of said package 6 and constitutes said window 11 for the emission of the light

beam 3. Moreover, its shape and size are such as to constitute also said diaphragm 12, thus forming a window/diaphragm/lens (11,12,13) (see, in particular, lens 13 shown in figure 4). In particular, the focusing lens 13 is a Fresnel or diffractive lens (manufactured by diffractive technology).

In a further alternative embodiment of the device of the present invention, shown in figure 4, the laser diode 2 is arranged into the package 6 so that the emitted light beam 3 propagates along a direction x that is substantially perpendicular to the longitudinal axis Z of package 6. Also in said embodiment, diaphragm 12 can be associated to the package 6 at the emission window 11, or housed into it or, preferably, it can consist of said emission window 11 suitably sized and shaped, as described above. The same for the focusing lens 13: it can be associated to the package 6 at the window/diaphragm 12, or housed into the window/diaphragm 12 and act itself as diaphragm, as described above.

Device 1 (and/or the optical element 20) of the present invention is particularly suitable for being mounted within an optical reader intended to acquire identification data of an illuminated object (not shown). Said reader also comprises means intended to generate a scan on the optical code to be read, photo-detecting means intended to collect a luminous signal diffused by the illuminated optical code and generate an electrical signal proportional thereto, and processing means intended to elaborate and process the electrical signal. In the specific case of an optical code reader, the processing means comprises an analogue/digital converter and a decoder.

During operation, with particular reference to figure 3, chip 4 of the laser diode 20 generates a laser beam 3 which is suitably truncated by window/diaphragm 12 and then focused by the focusing lens 13 on a desired reading area (wherein, for example, an optical code to be identified is

present). On the other hand, with reference to figure 4, chip 4 of the laser diode 20 generates a laser beam 3 which is suitably stopped and focused by the window/diaphragm/lens 11,12,13 on a desired reading area (wherein, for example, an optical code to be identified is present). When device 1 is used in an optical reader, the luminous signal diffused by the illuminated optical code is detected by the photo-detecting means arranged in the same reader, and afterwards it is processed to acquire the desired information. In the specific case of an optical code reader, the luminous signal is detected as analogue electrical signal, converted into digital and then decoded.

Reference shall now be made to figures 6, 7 and 8, which show a non-retroreflective scan optical reader 100 comprising an optical emission/detection device 101 of a luminous signal in accordance with the present invention. From the structural point of view, said device 101 is substantially equal to the conventional emission source 2 shown in figure 1 (or in some of its alternative embodiments, to the emission device shown in figure 2, 3 or 4), with the exception of comprising a package 60 having a substantially parallelepipedal shape and that the cavity of package 60 is divided into two portions 60a and 60b optically separated by an intermediate wall 102 made of an optically opaque material.

Portion 60a of package 60 houses the means for generating the light beam described above with reference to figure 1. Portion 60b houses a photodiode 103 for collecting and detecting the luminous beam diffused by an optical code 104 illuminated by the above means for generating the light beam 3.

Portion 60b is provided with a window 105 for collecting the light beam diffused by the optical code 104. Said window is formed on a wall 106 substantially orthogonal to wall 107 on which the window 11 for the emission of the light beam 3 is formed (in other words, wall 107 is

substantially parallel to the code plane 104).

The light beam 3 generated in the device 101 impinges at 45° on a rotating or oscillating mirror 140 of a mirror polygonal rotor 150, which generates a scan in a substantially orthogonal direction with respect to the emission direction of light beam 3; the beam thus deviated impinges on the optical code 104 and the light diffused thereby is collected by the photodiode 103. Therefore, the emission and collecting optical paths are totally separate from one another.

Figures 7 and 8 show in detail the internal structure of this device. Package 60, made of a plastic, metal or ceramic material, essentially consists of three layers (however, there could also be only two of them): the first one, referred to with reference numeral 110, is the base wherein some tracks 111 for connecting the photodiode contacts 112 are formed. Onto said base 110 there are mounted the monitor photodiode 8, the chip 4 of the laser diode (which can be of the side emission type, SEL, or vertical emission, VCSEL) on a support 5 made of a thermally conductive material, and the reception photodiode 103. Then, on the first layer 110 a second layer 120 is mounted, wherein the window 11 is obtained (optionally, said window may act as diaphragm 12 or as diaphragm/lens 13, as described above). Said layer 120 concurrently serves as spacer between the layer 110 and a third layer 130, wherein the window 105 (of transparent material) for collecting the light beam diffused by the illuminated optical code 104 is obtained. The reception photodiode 103 is thus in a slightly rear position with respect to the gathering window 105, and therefore it is partly screened with respect to the light coming from different areas than that illuminated by the emission beam (ambient light), thus improving the signal-noise ratio at the output from photodiode 103.

The intermediate wall 102 is made of an optically opaque



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